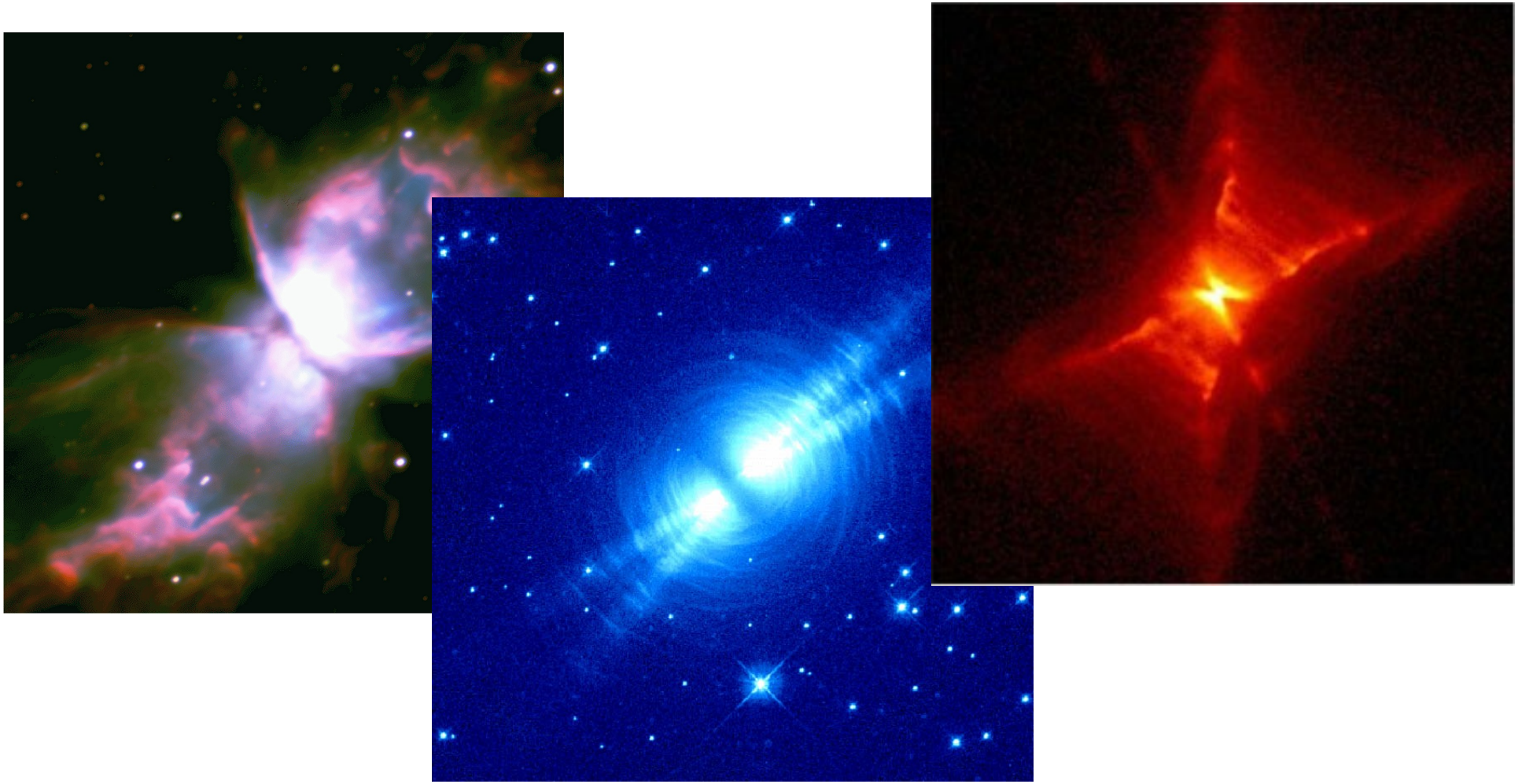
Dust tutorial 4

Circumstellar, interstellar and extragalactic dust

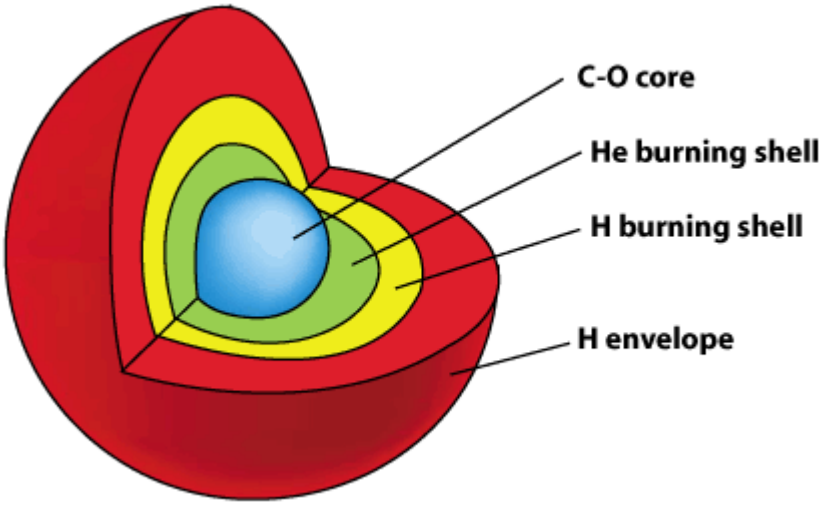
Ciska Kemper
10 May 2011

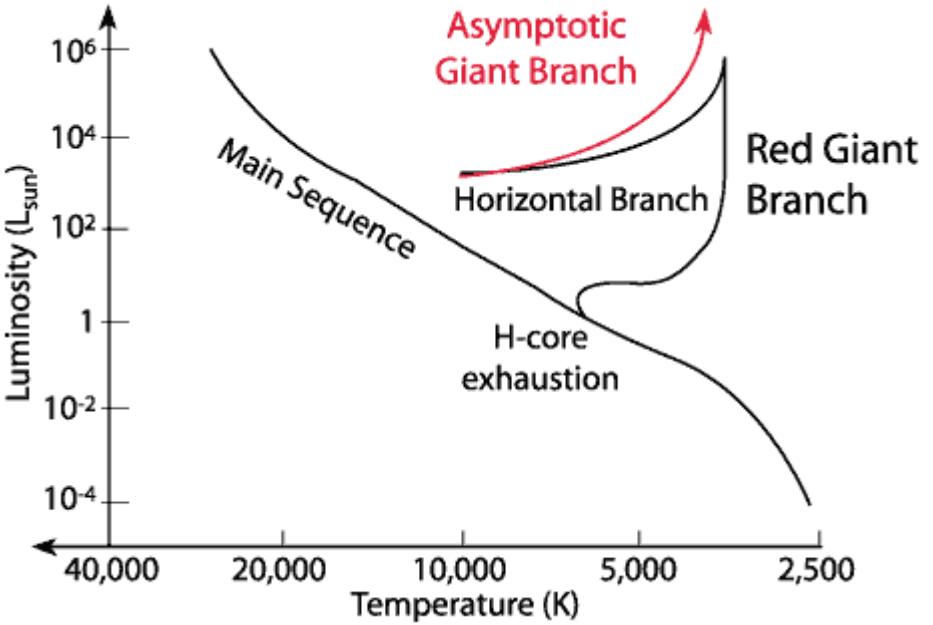
Circumstellar & Interstellar dust

Old stars have young dust…

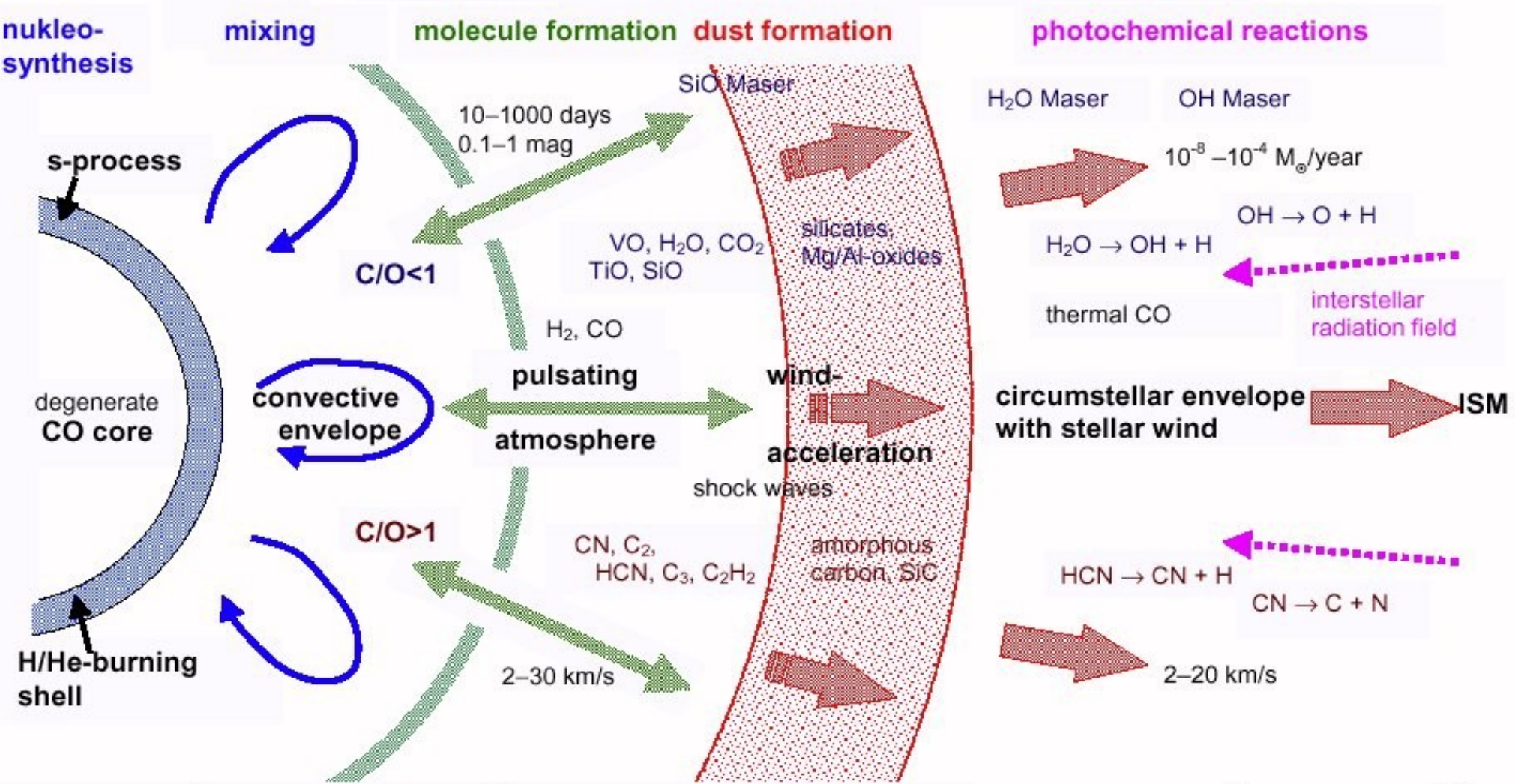


Asymptotic Giant Branch stars





Schematic view of an AGB star

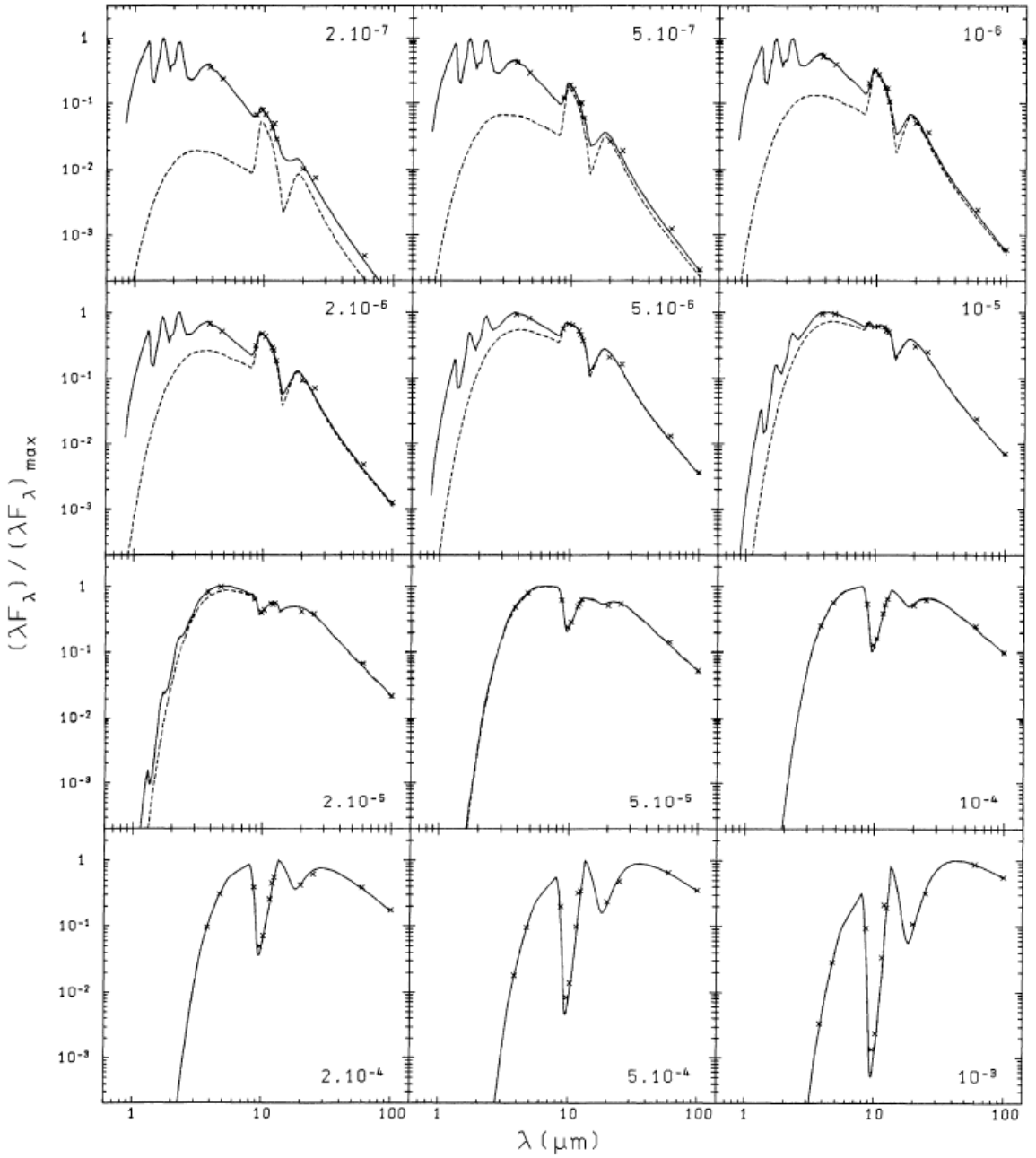


10^8	10^{13}	10^{14}	r [cm]	10^{16}	10^{18}
10^8	3000	1000	T [K]	100	20
10^{30}	10^{13}	10^{6-9}	n [cm^{-3}]	10^{2-5}	0.1-10

$1R_{sun} \sim 7 \cdot 10^{10}$, $1AU \sim 1.5 \cdot 10^{13}$, $1pc \sim 3 \cdot 10^{18}$cm

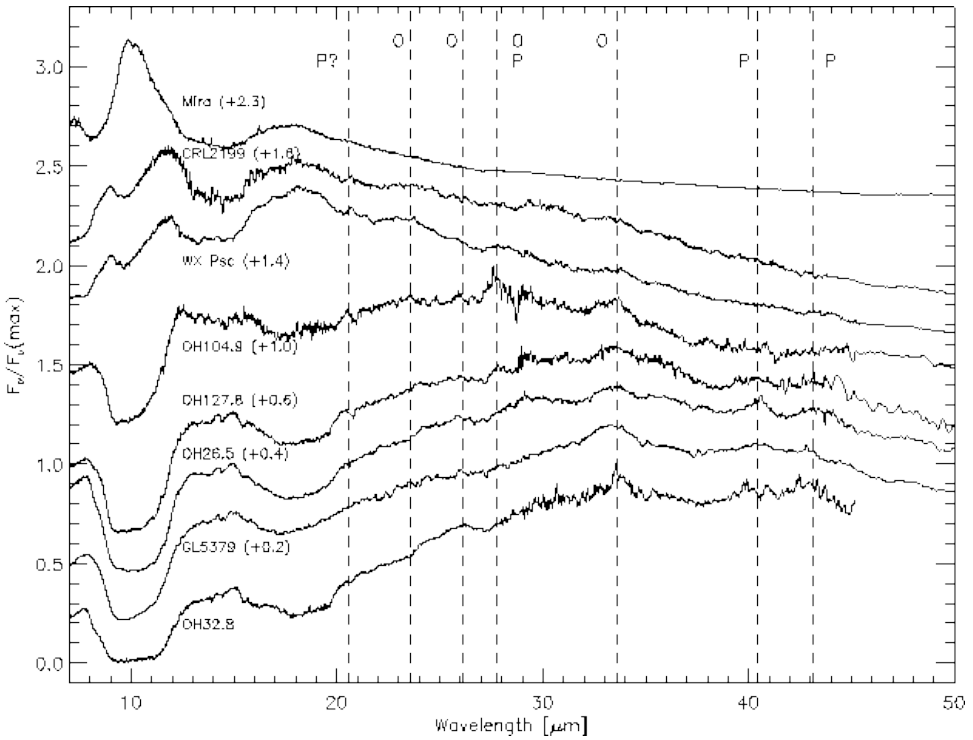
J. Hron, Inst. for Astronomy, Univ. of Vienna

Dusty winds & O-rich AGB stars

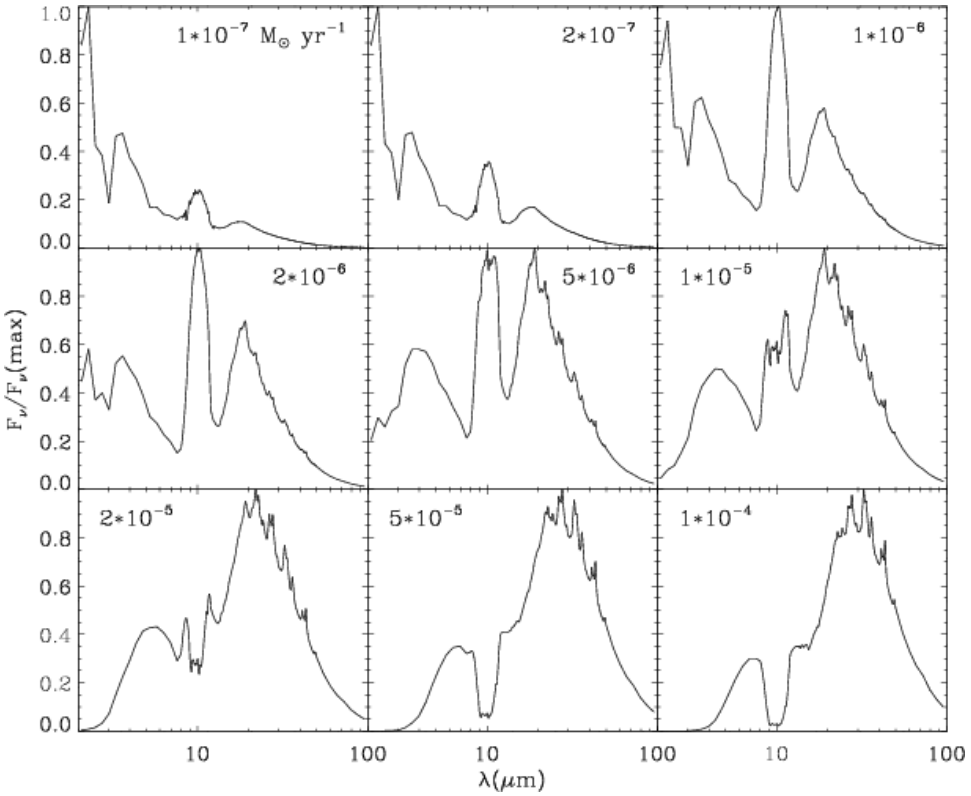


(Bedijn 1987)

Crystallization of silicates

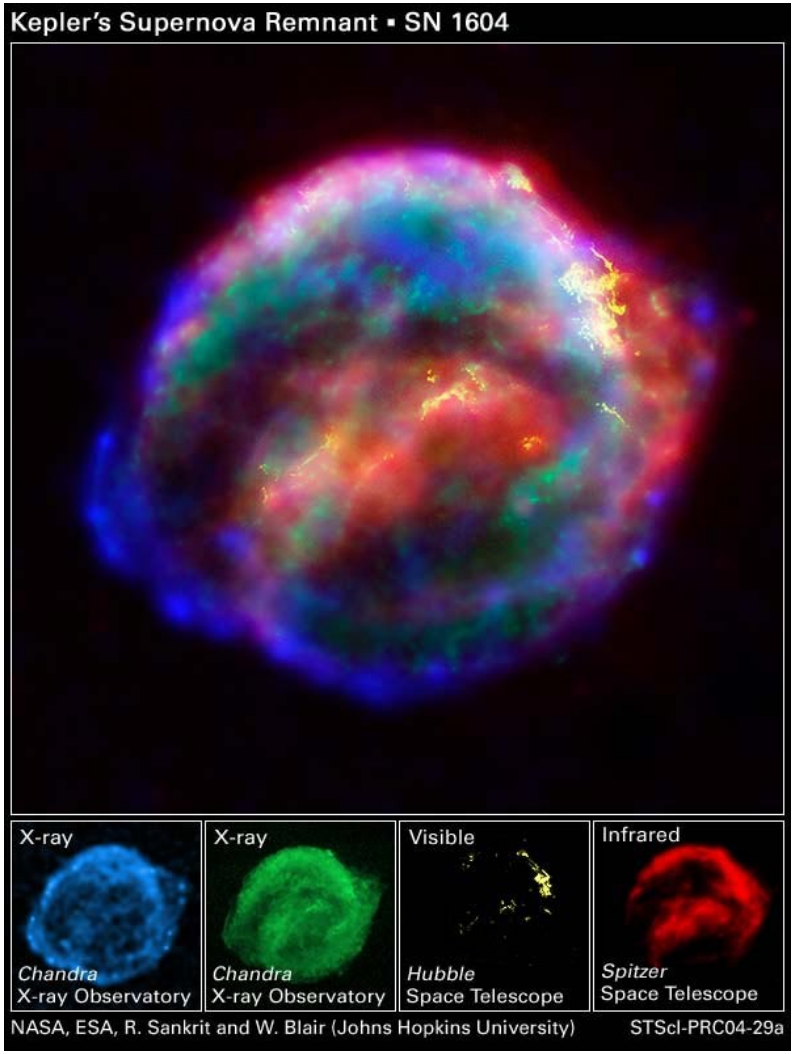


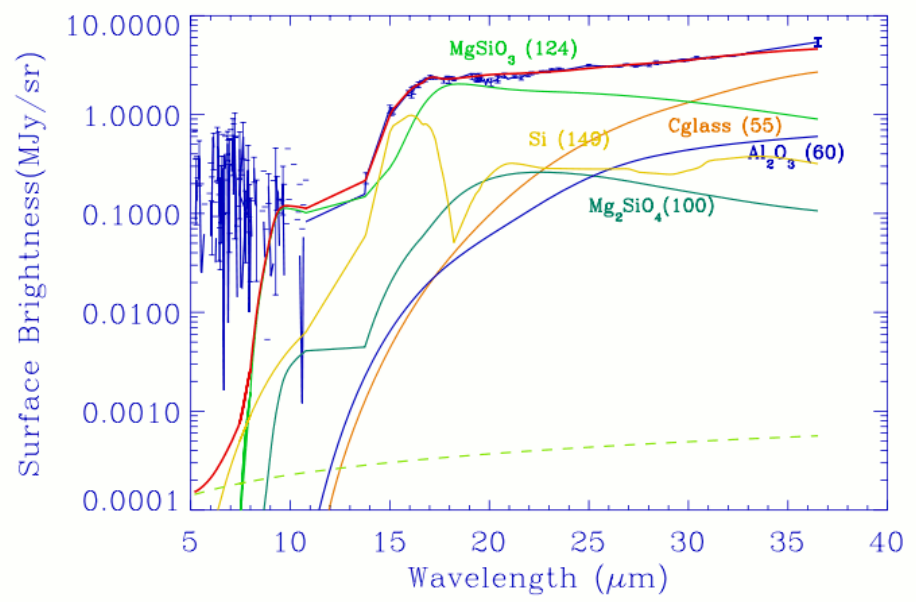
Sylvester et al. (1999)



Kemper et al. (2001)

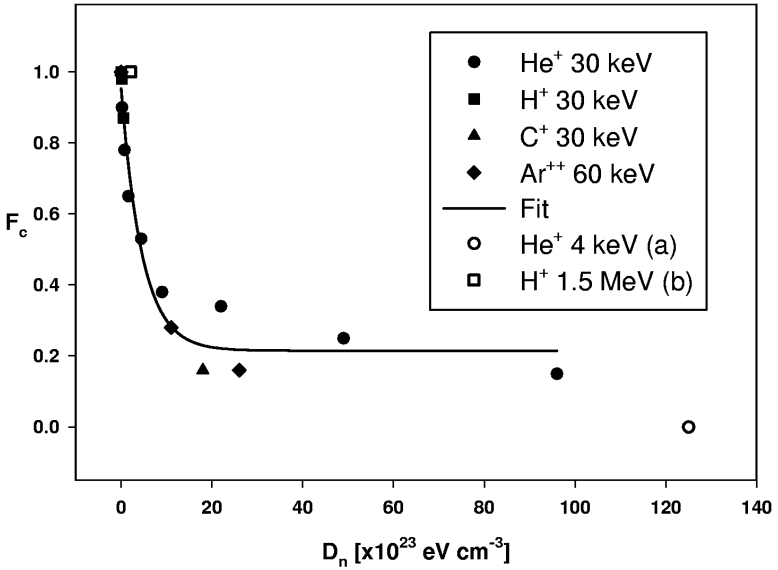
What do we know about SN dust?

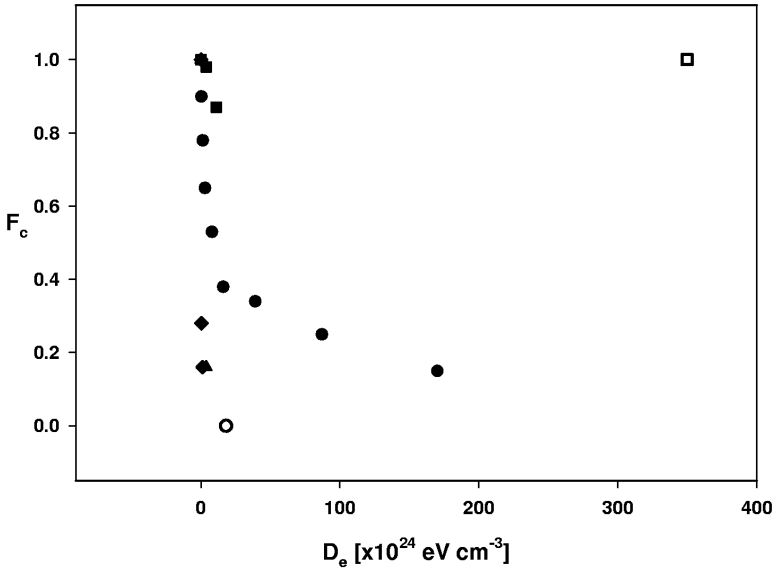


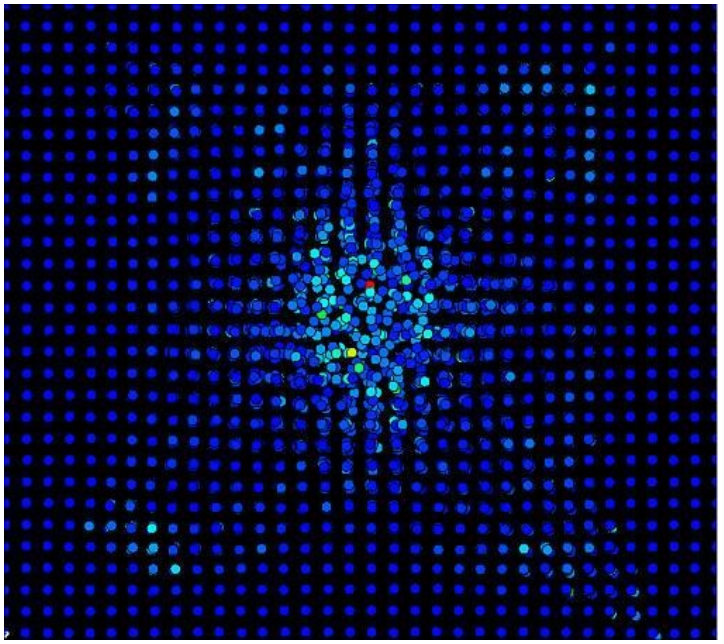


Rho et al. 2009

. . . mid-life in the ISM . . .





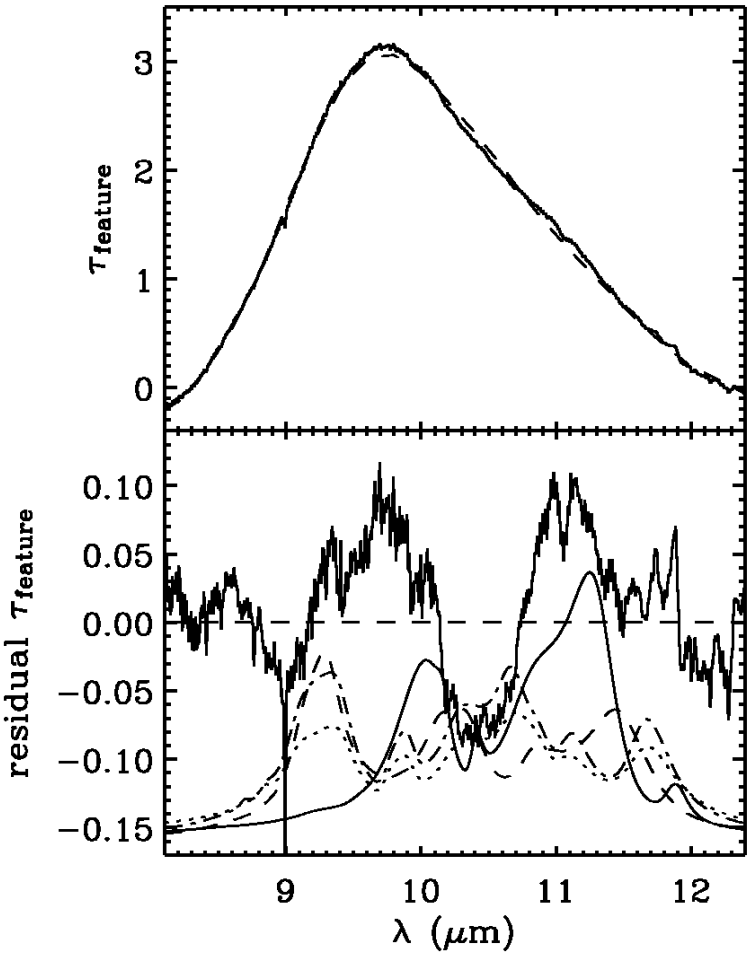


Brucato et al. (2004)

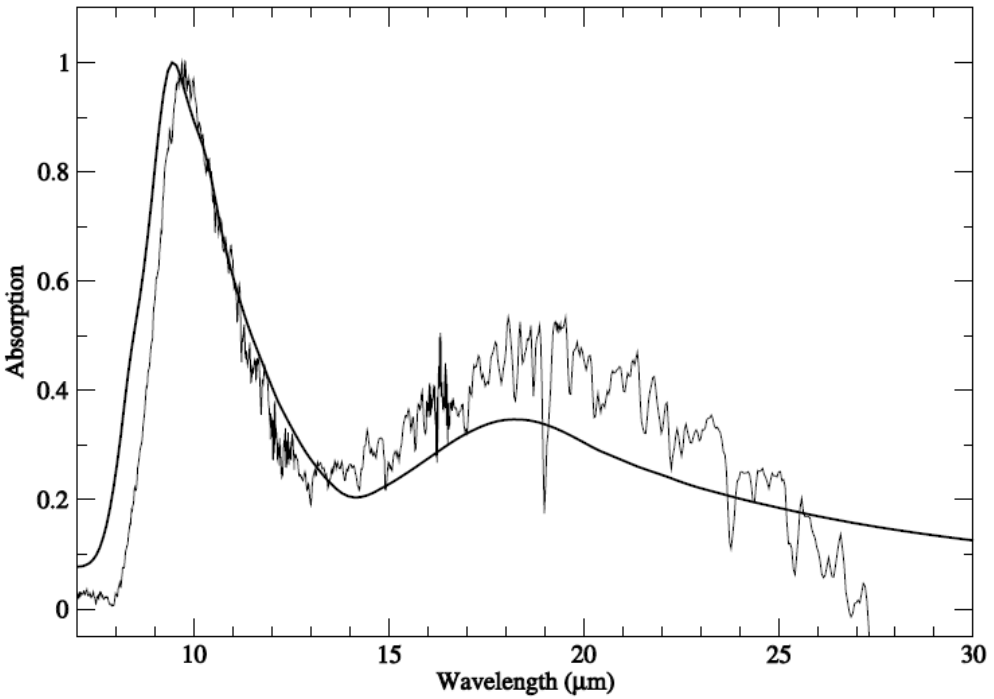
Featureless broad resonance at 10 micron

→

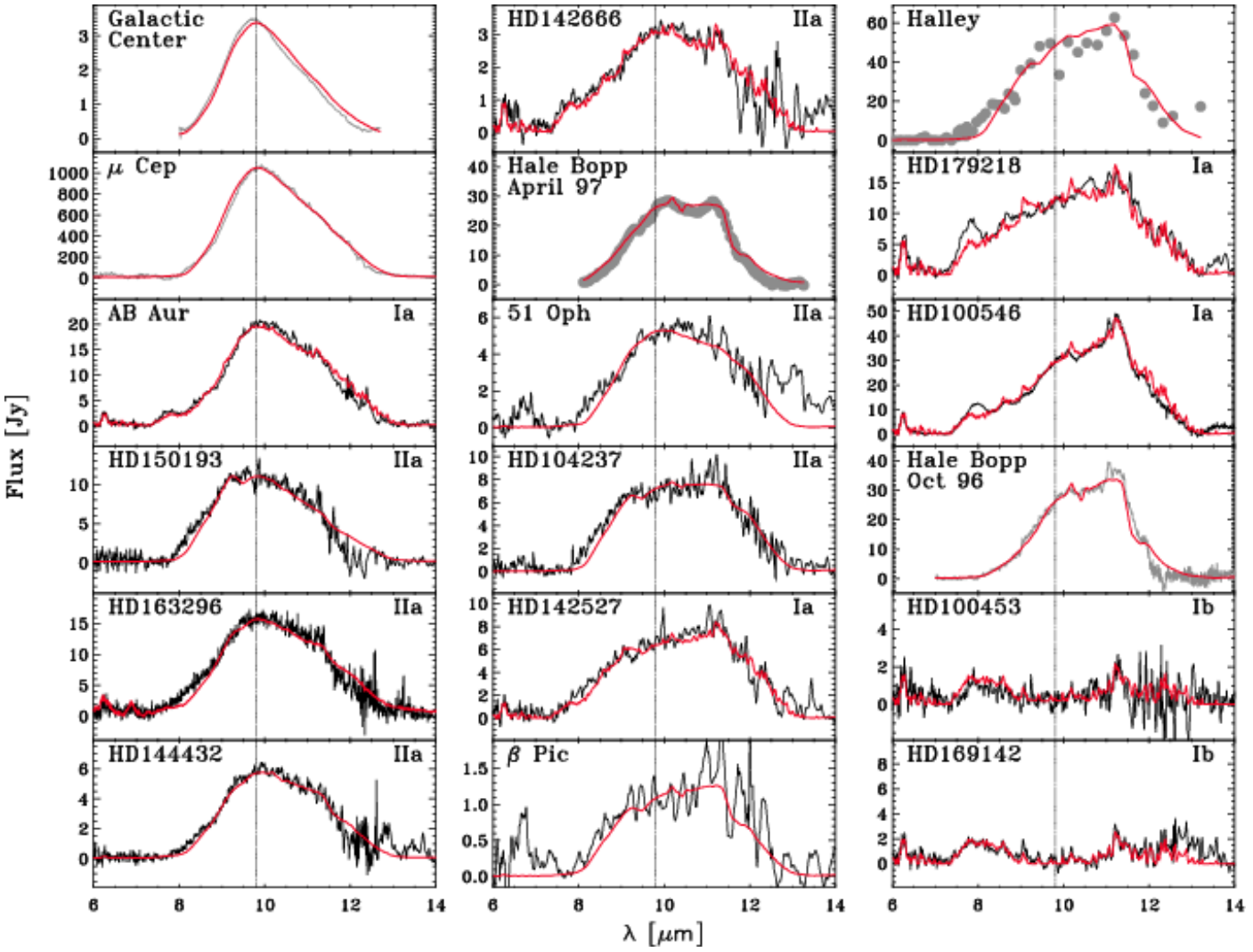
Most silicate grains in the ISM are amorphous



Kemper et al. 2004; Chiar & Tielens 2006

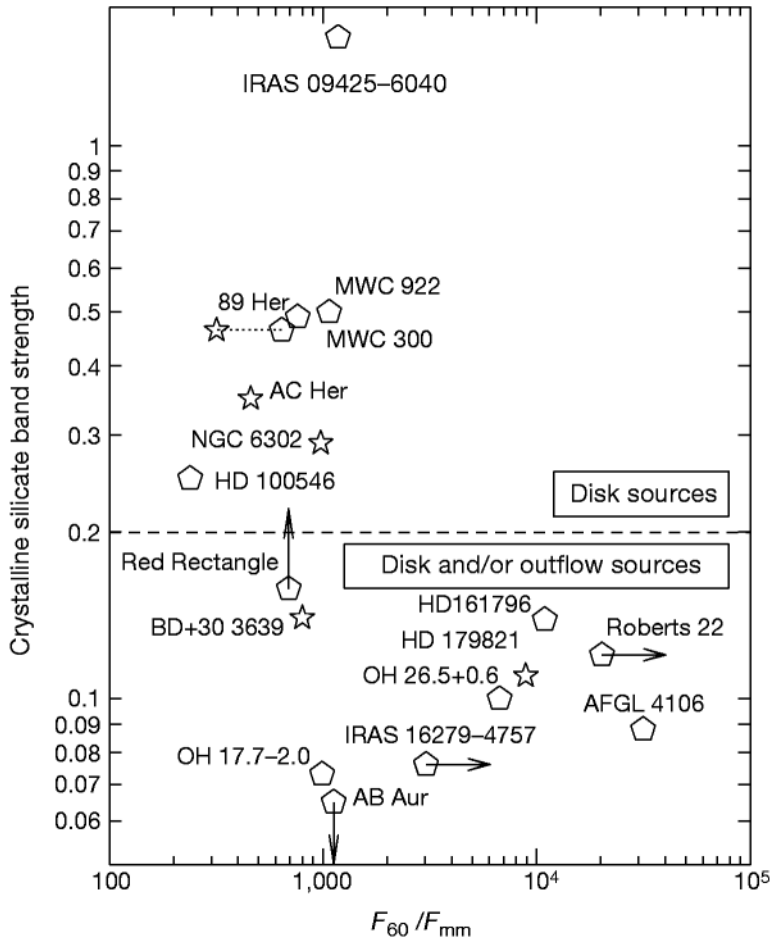


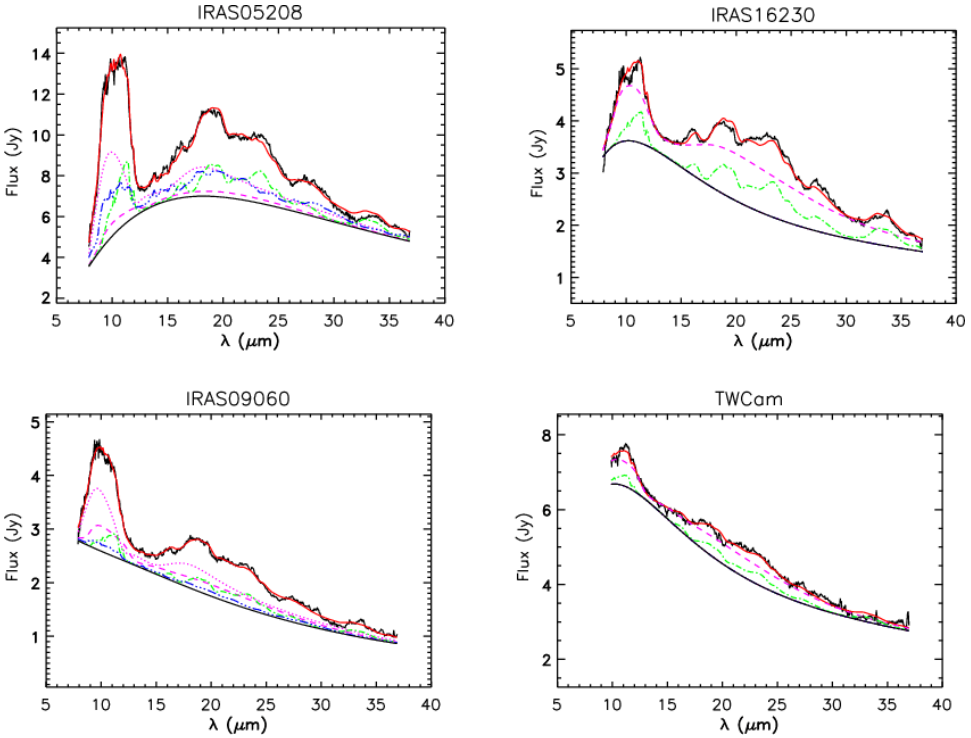
. . . and young stars have old dust



Bouwman et al. 2001

Disks & Crystallization (in evolved stars)



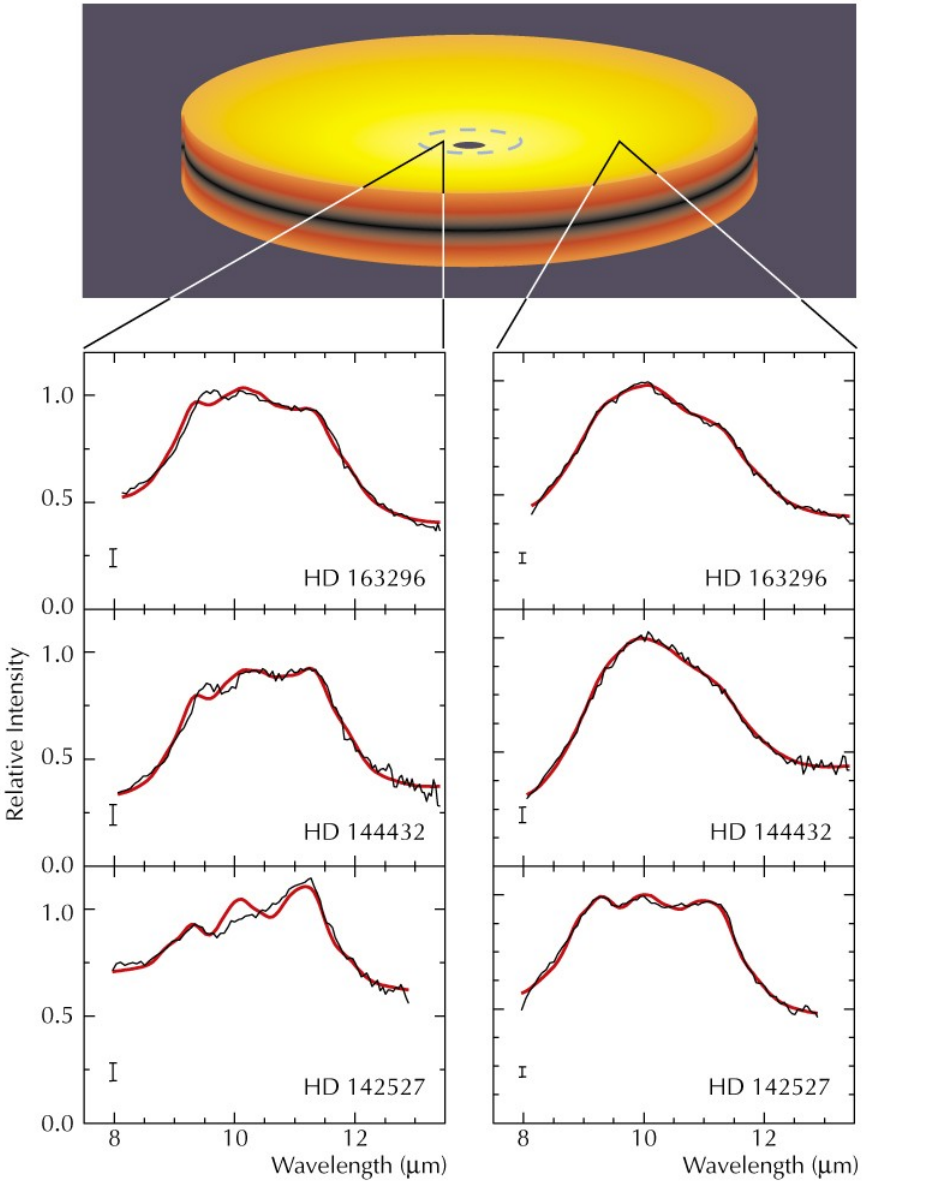


Gielen et al. (2008)

Molster et al. (1999)

Spatial variations within protoplanetary disk

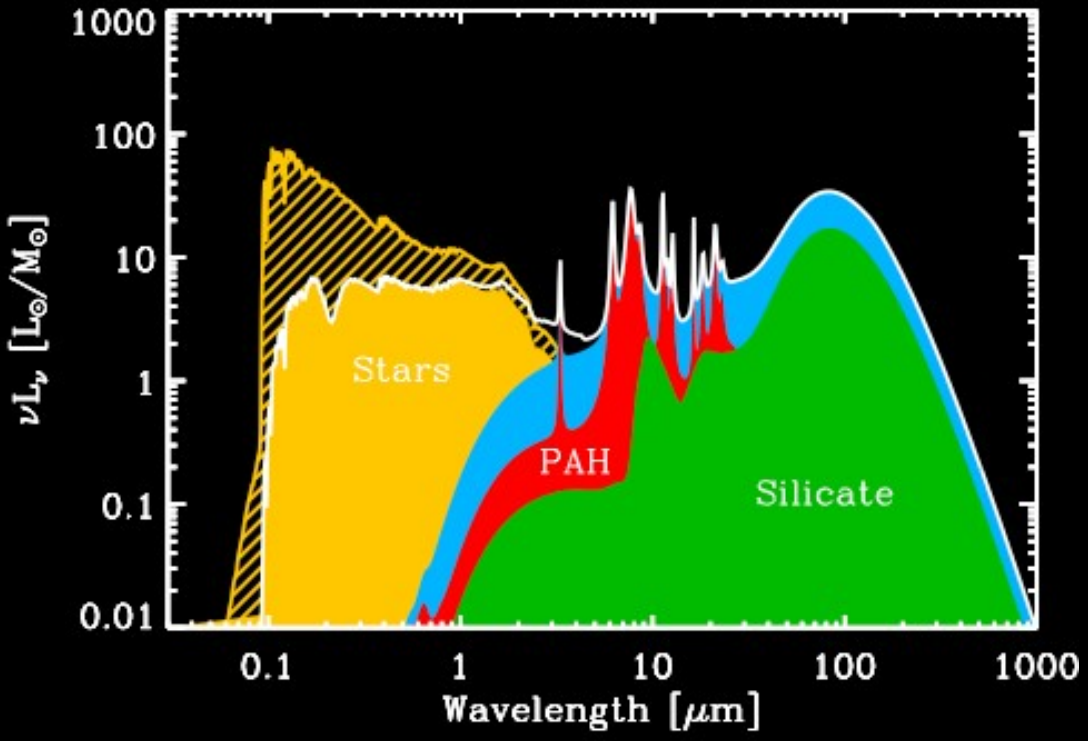
van Boekel et al. (2004)

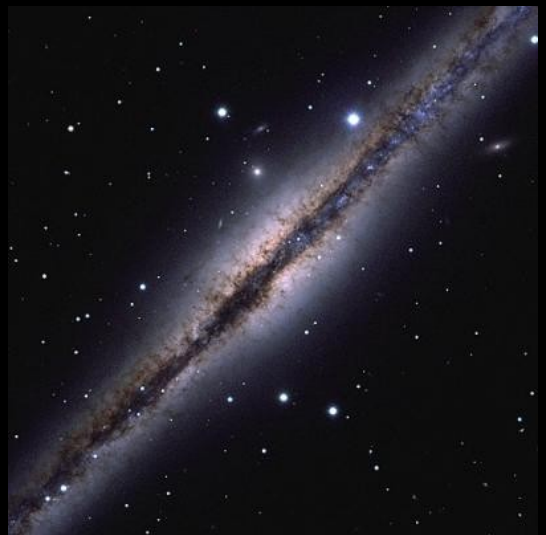


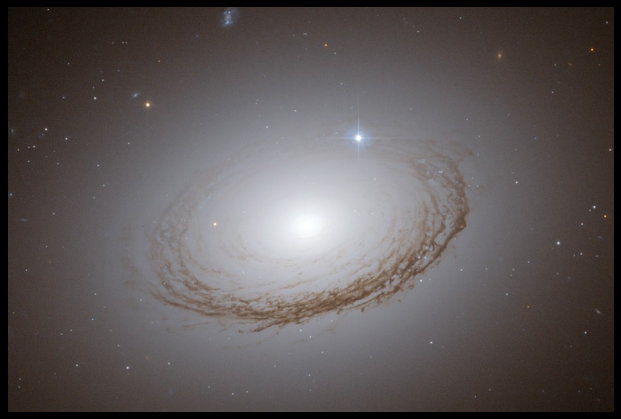
Mid-IR Spectra of Inner and Outer Discs Around Three Young Stars

ESO PR Photo 32b/04 (24 November 2004)

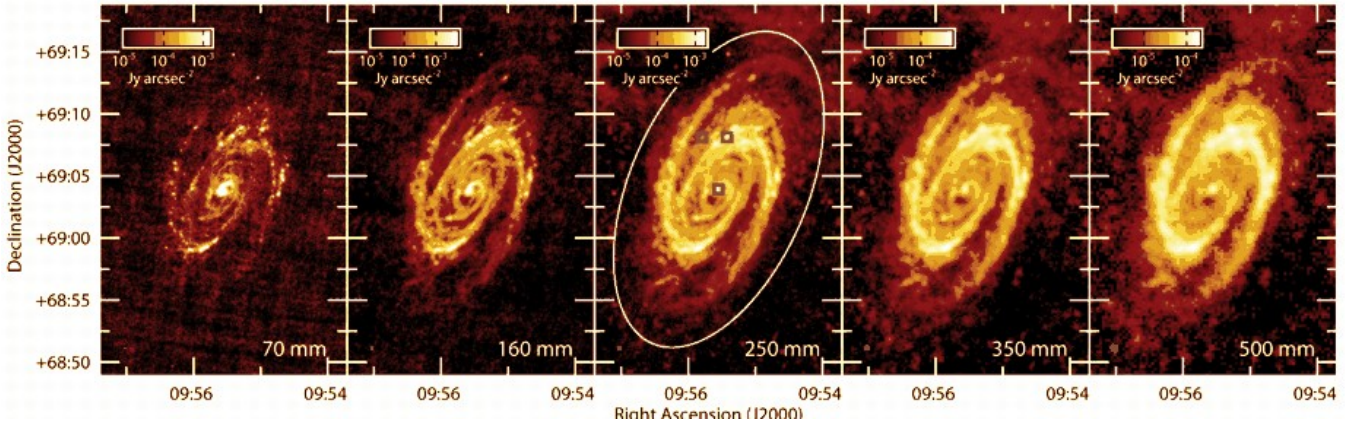
Dusty galaxies



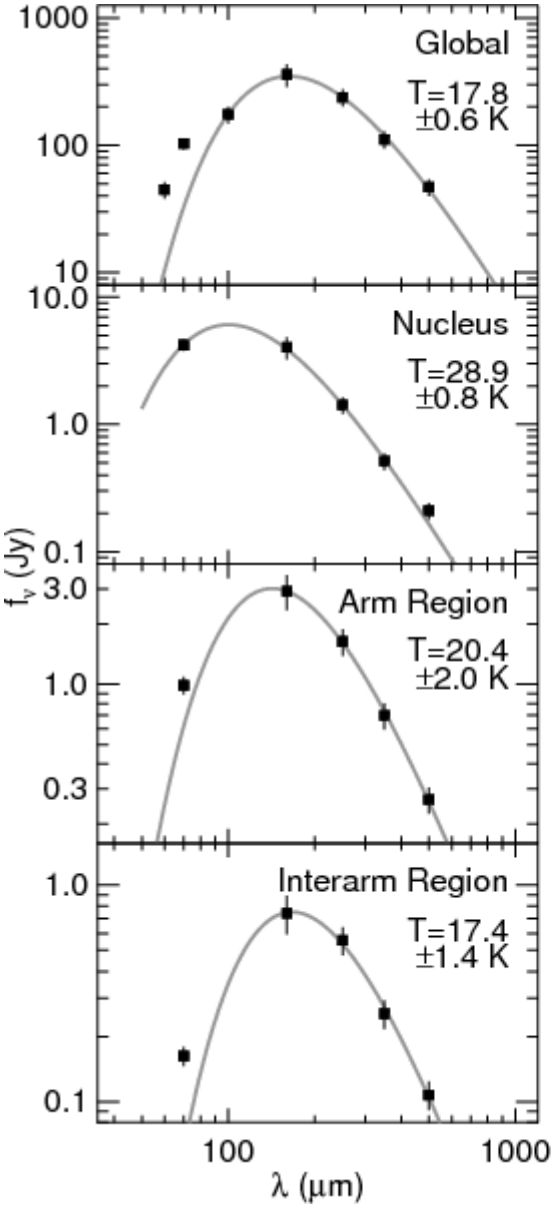




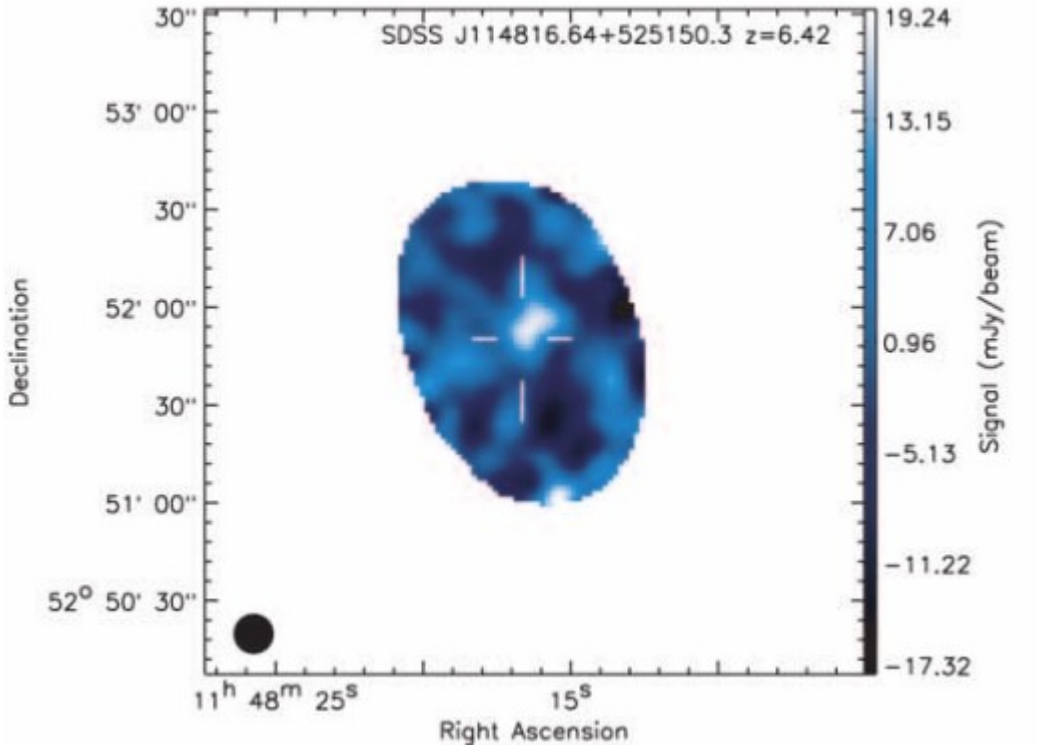
Dust masses in the far-IR/submm

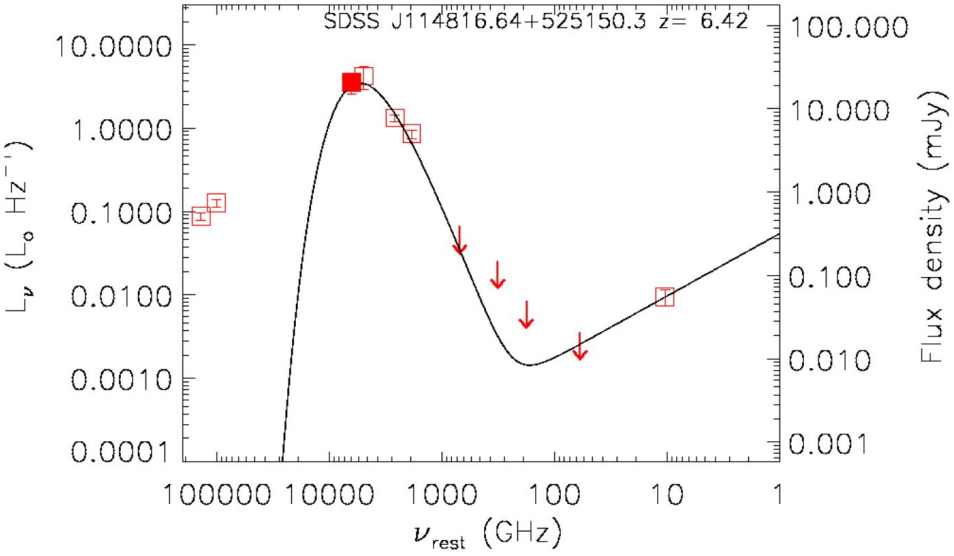


- Example: M81 *(Bendo et al. 2010)*
- Fitting SEDs
- Bulk of dust is cold -> far-IR/submm
- Dust mass derived: 3.4 10^7 M_{sun}



Dust at z=6.42





SHARC II @ CSO - 350 micron *(Beelen et al. 2006)*

Dust mass: $4.2\ 10^8\ M_{sun}$

AGB stars have not built up sufficient amounts of dust; the Universe is < 1 Gyr old

Dust at high redshift

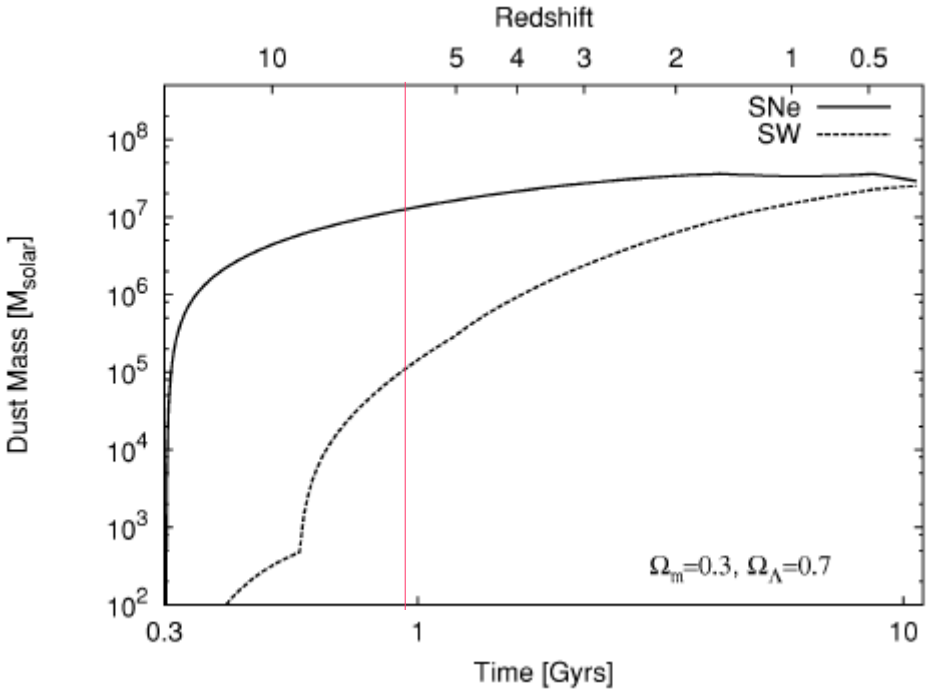
z~6 quasar host galaxies: 10^8 – 10^9 $M_\odot$

of dust *(Priddey et al. 2003; Beelen et al. 2006)*

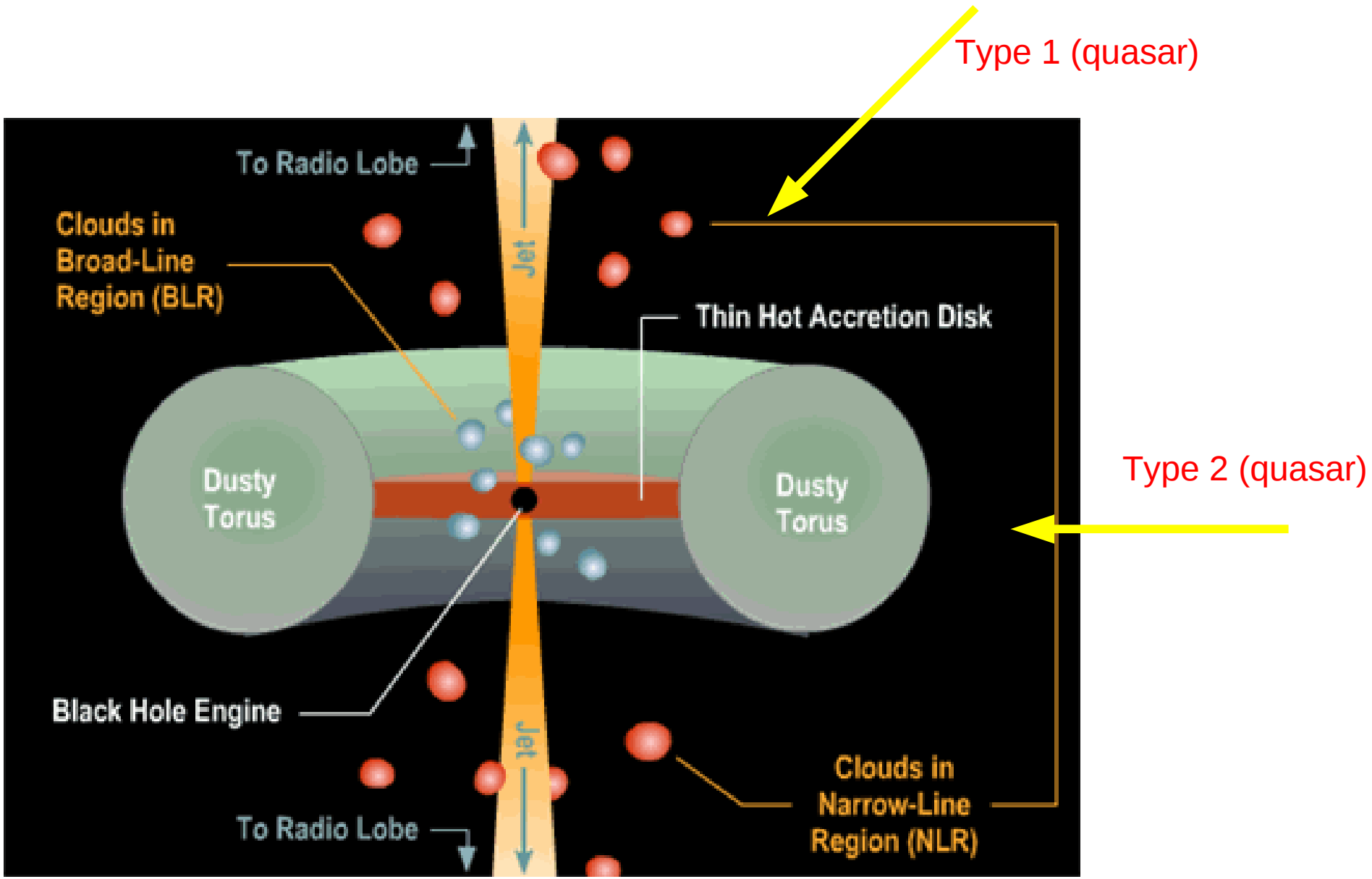
The Universe is only <1 Gyr old at that point

AGB evolution does not produce enough dust *(Morgan & Edmunds 2003)*

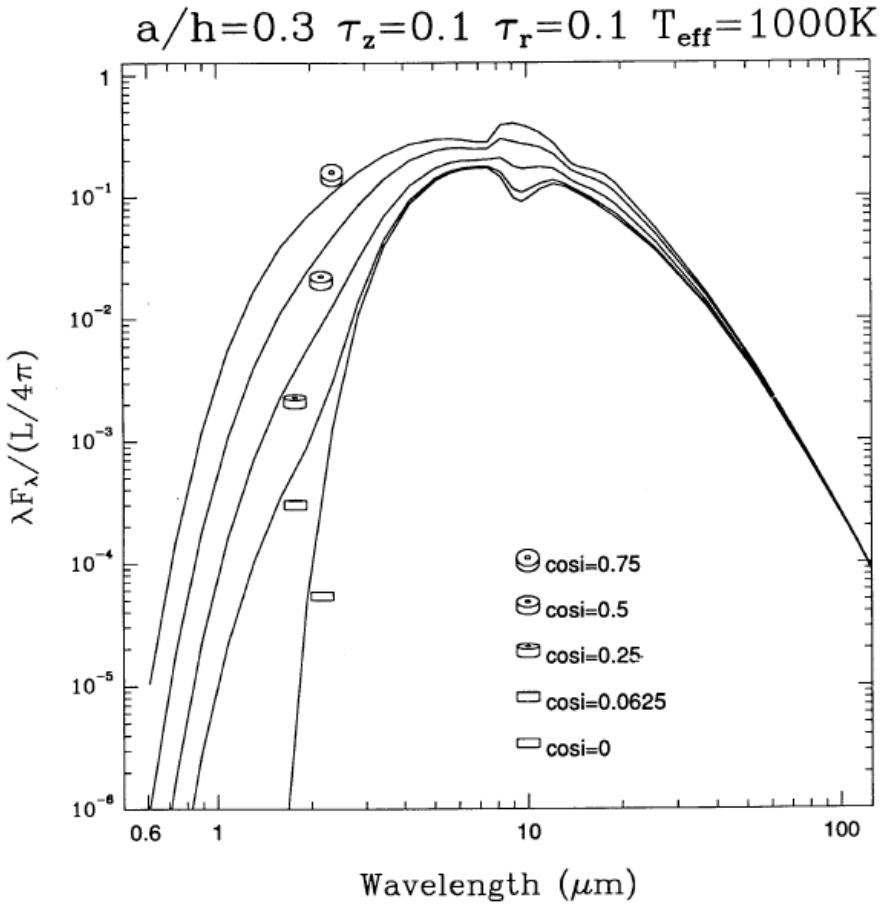
Supernovae?



The physical model for AGN



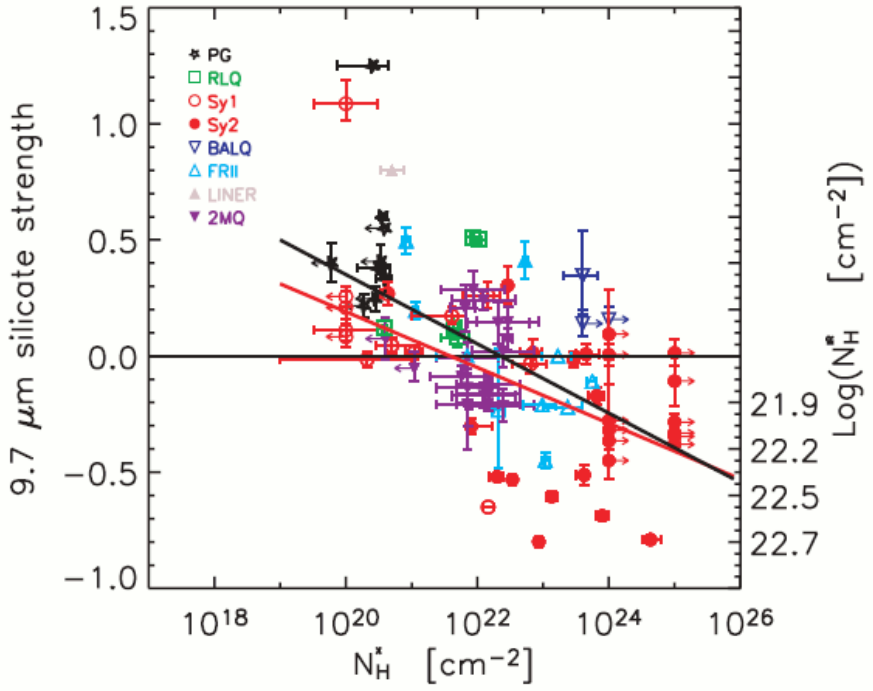
Spectral Energy Distributions

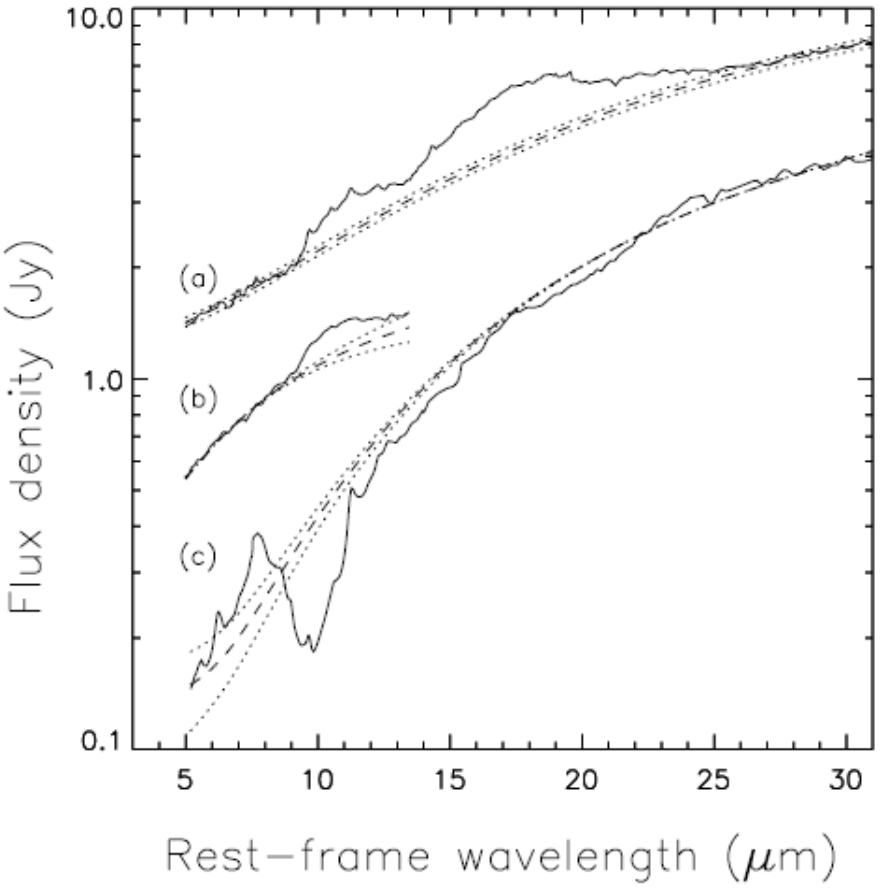


Pier & Krolik 1992

- Pier & Krolik
- Nenkova et al.
- Van Bemmel & Dullemond
- Hönig et al.
- Fritz et al.
- ...

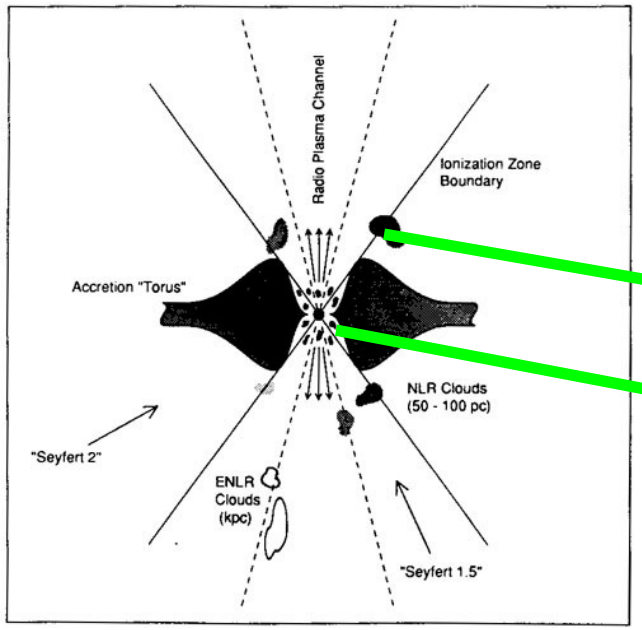
Silicates in AGN: typically only optical depth, emission & absorption

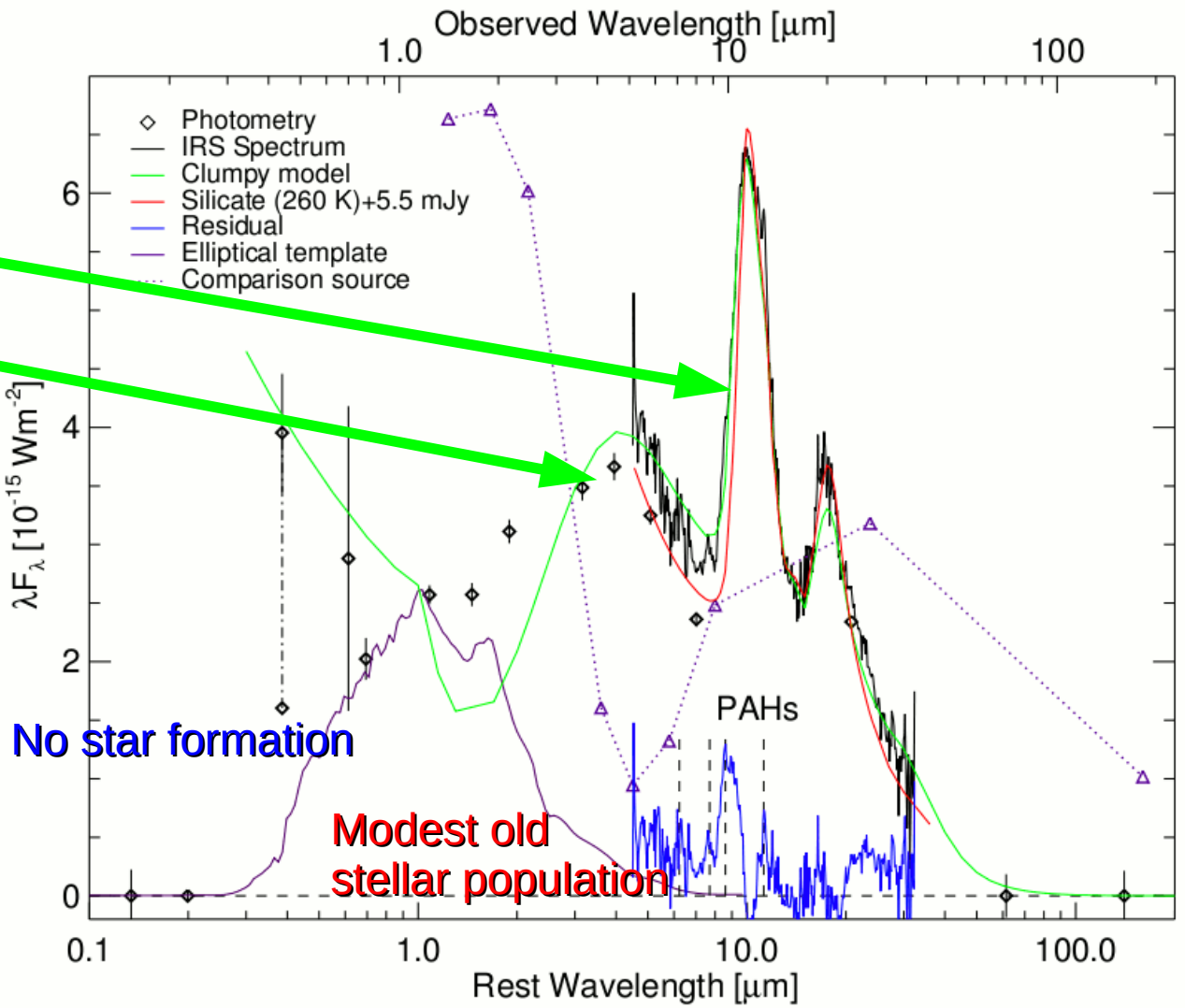




Shi et al. 2006

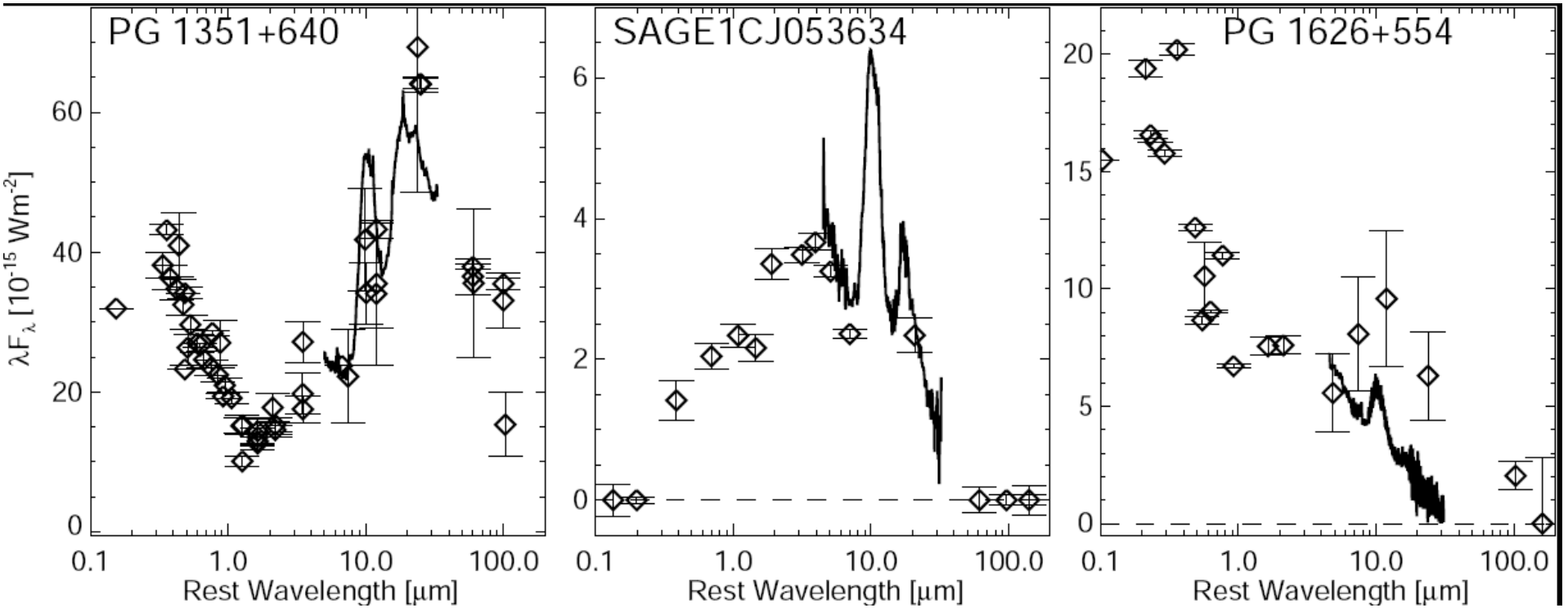
A case of extreme emission: host galaxy hardly detected





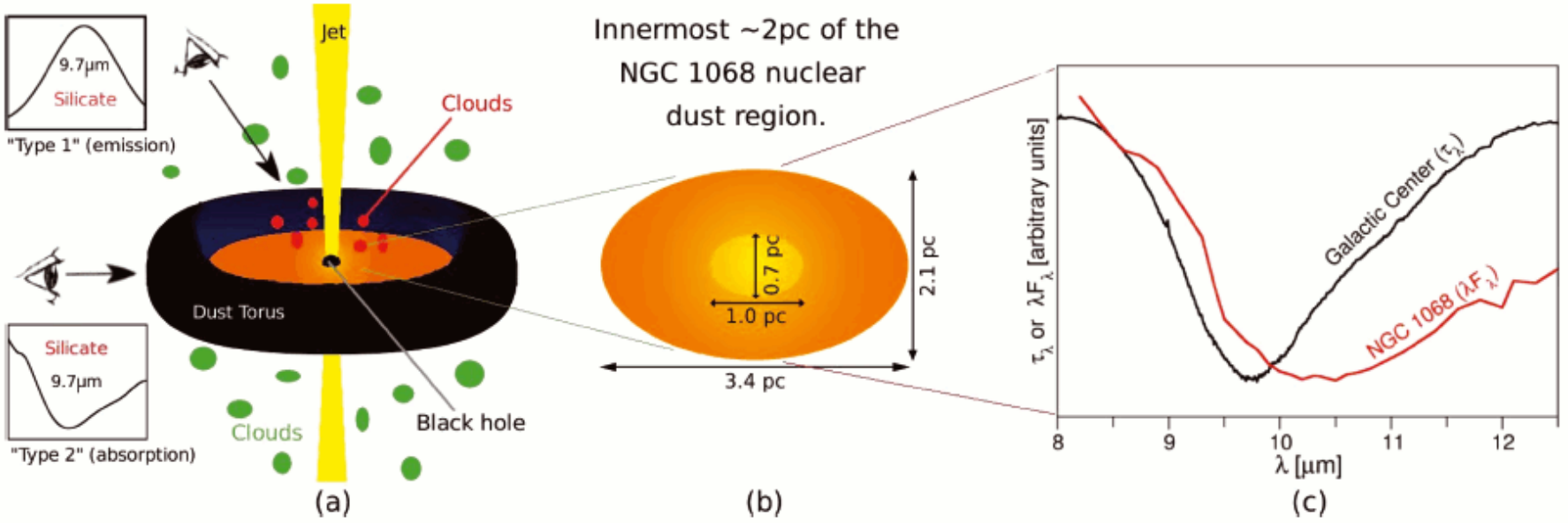
Hony et al. 2011

Extreme silicate emission

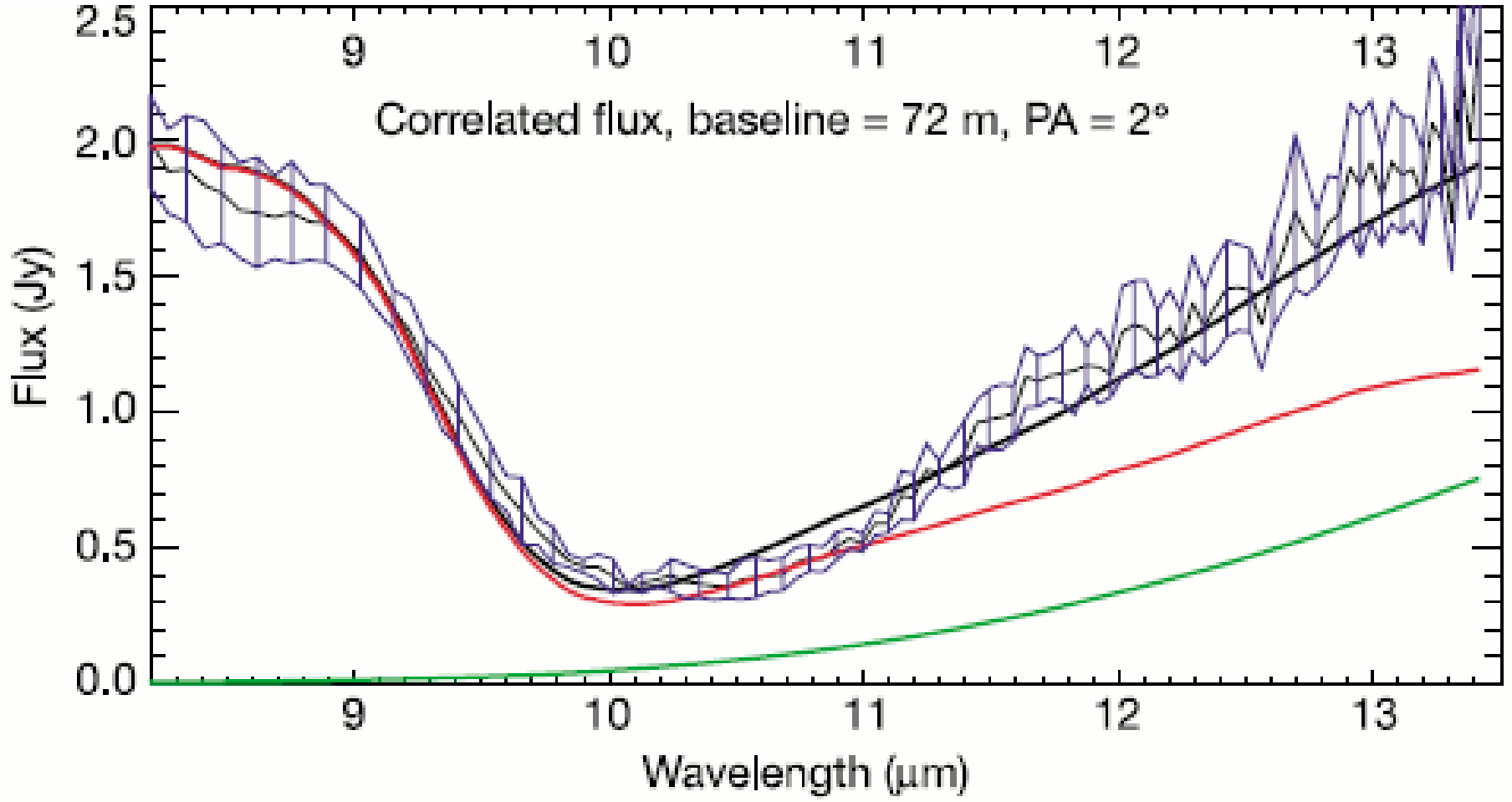


Hony et al. 2011

Odd mineralogies: NGC 1068

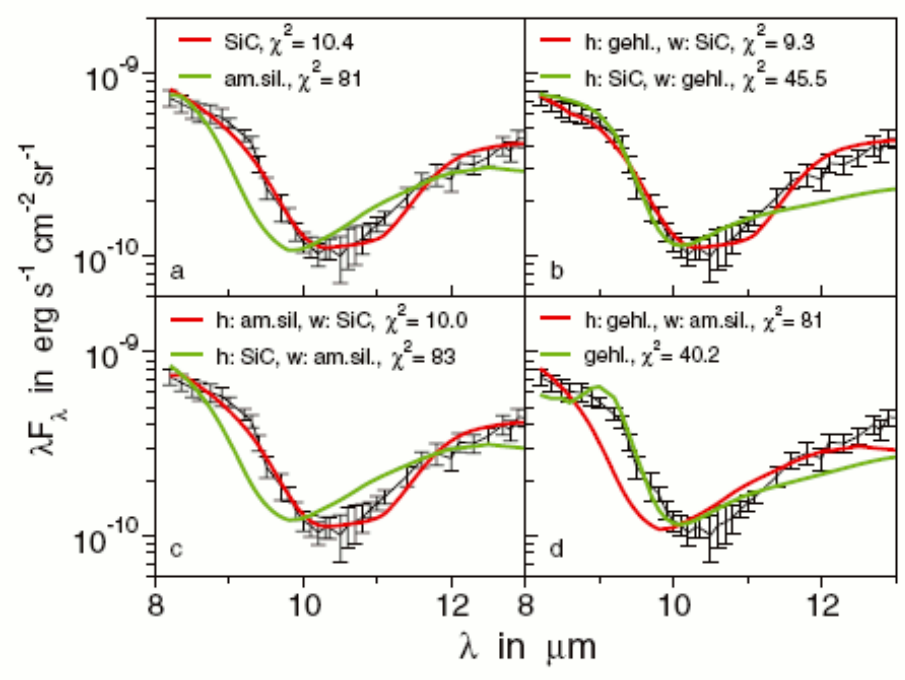


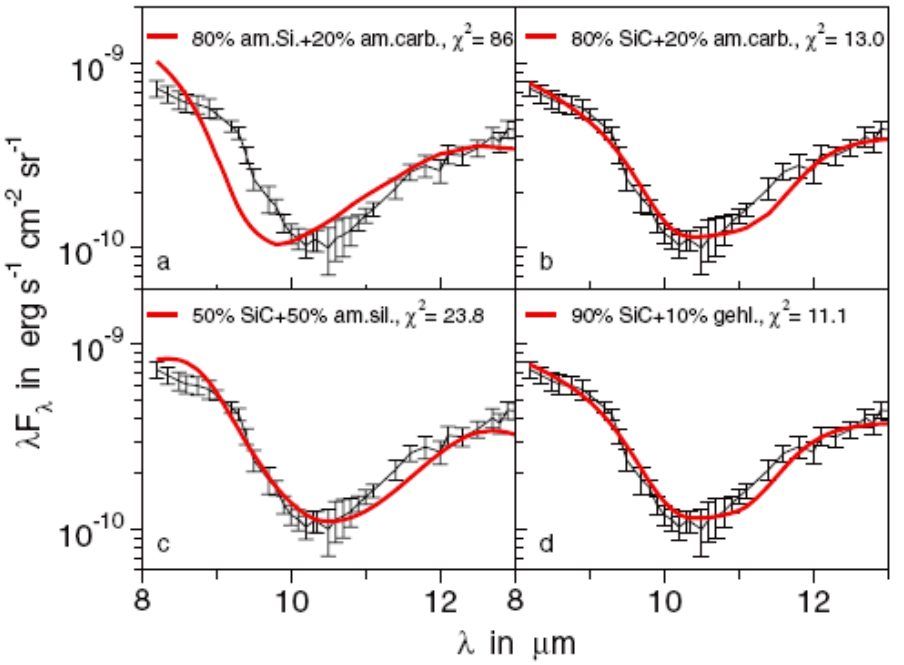
Odd mineralogies: gehlenite (Al-Ca-silicates) in NGC 1068?



Jaffe et al. 2004

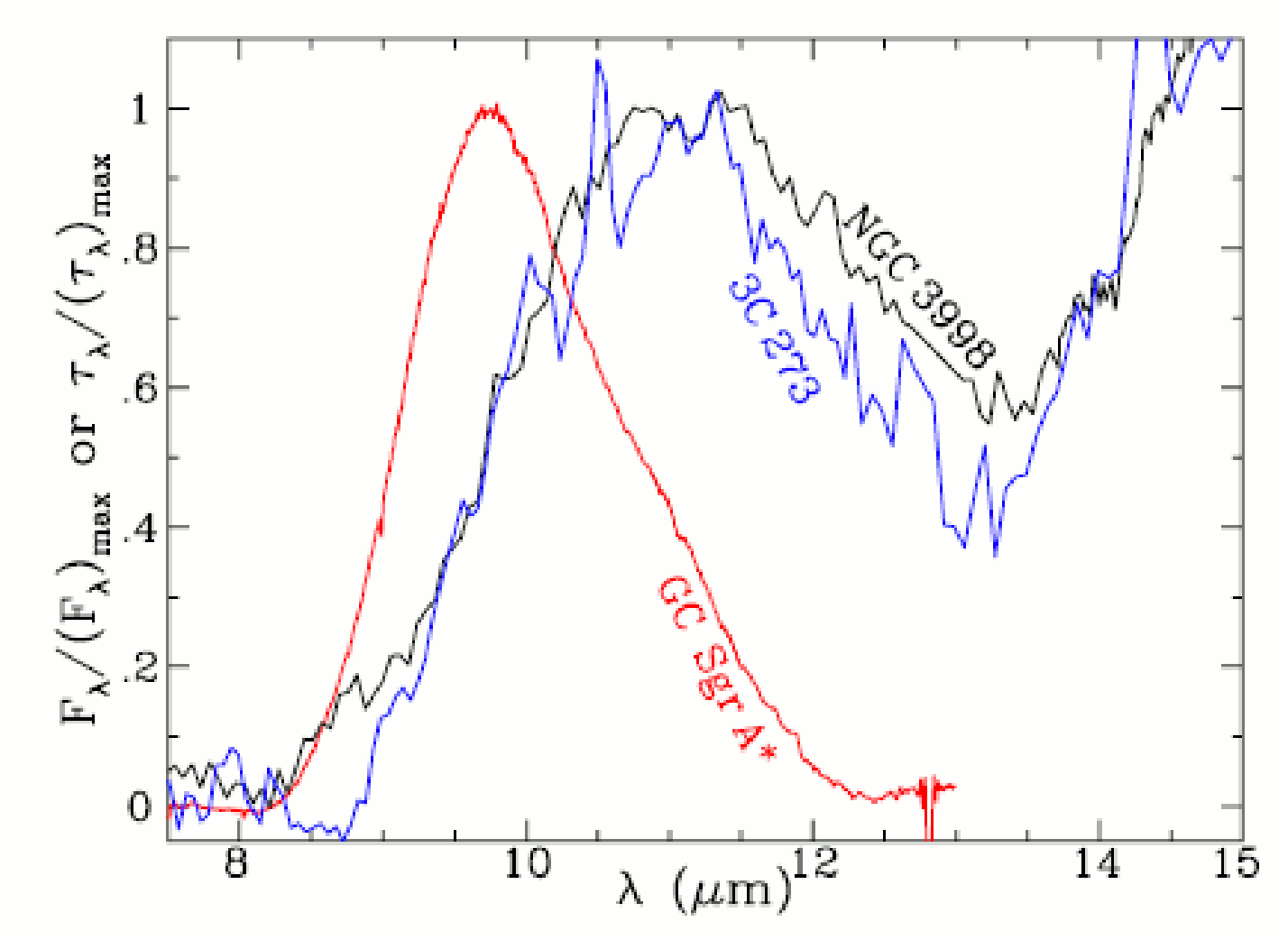
Odd mineralogies: SiC in NGC 1068?





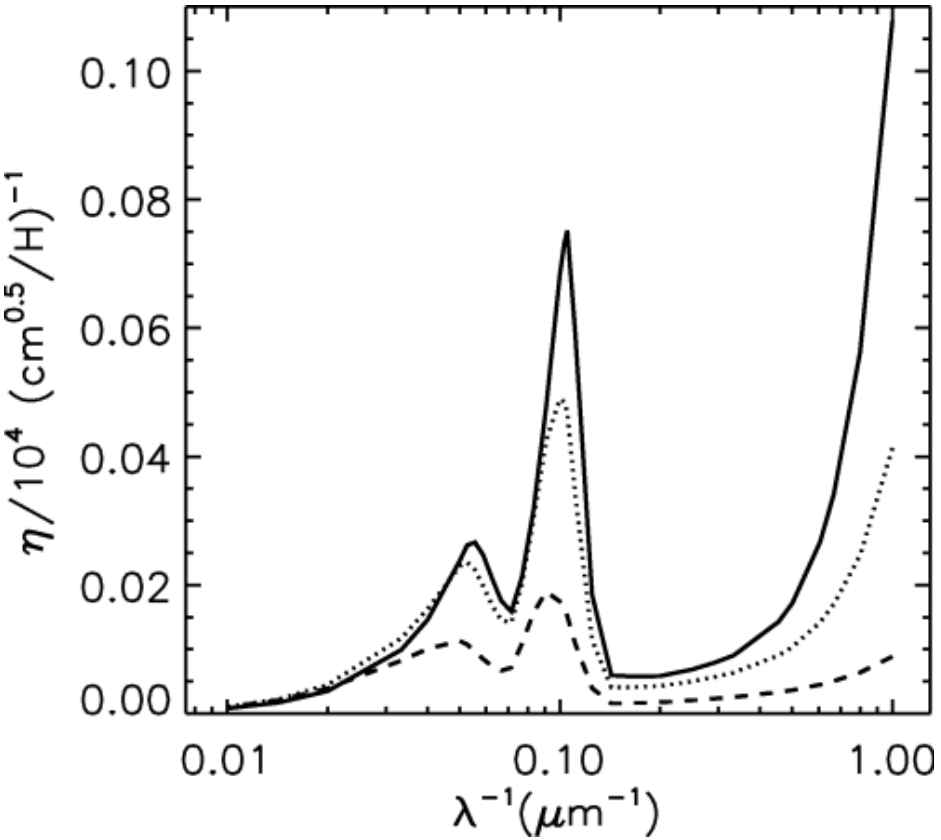
Köhler & Li 2010

Odd mineralogies: Porous silicates

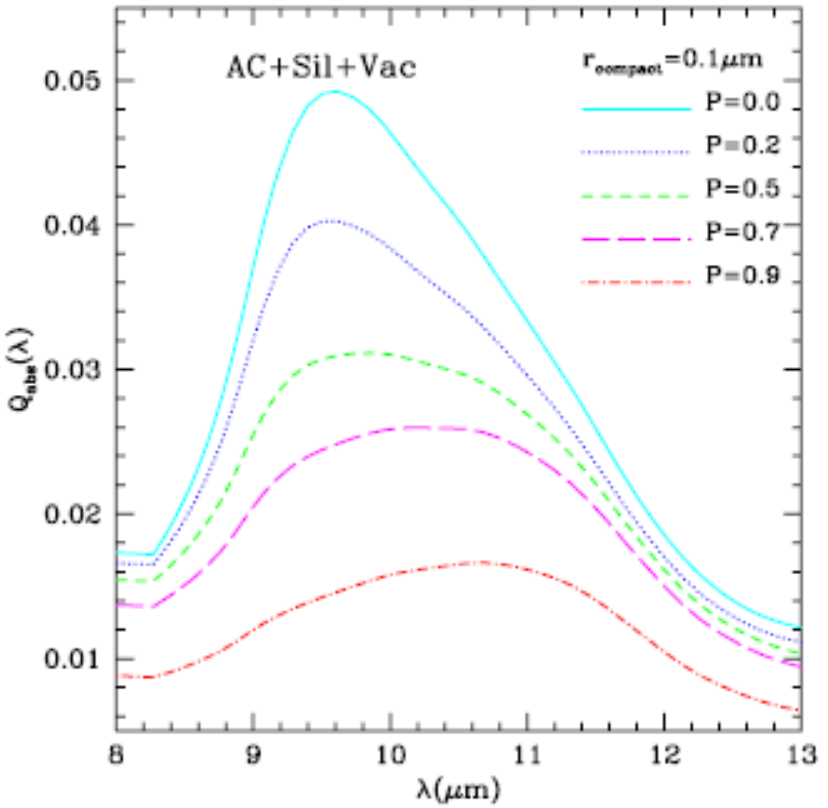


Hao et al. 2005; Sturm et al. 2005

Porosity shifts & weakens 10 micron feature

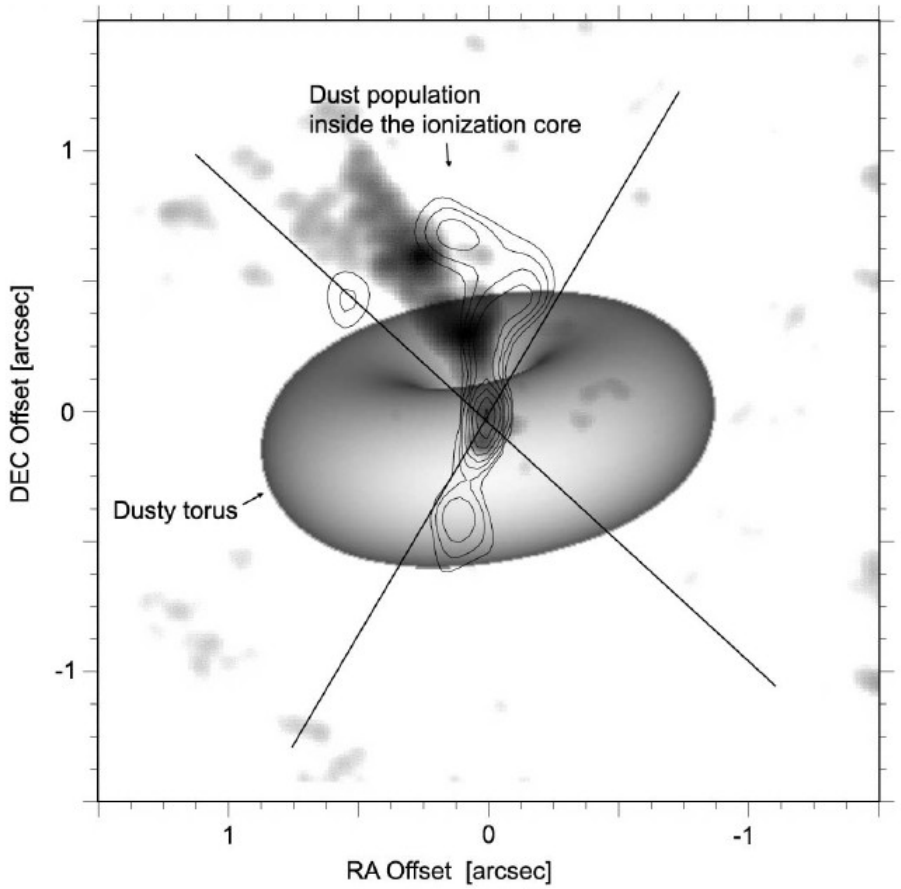


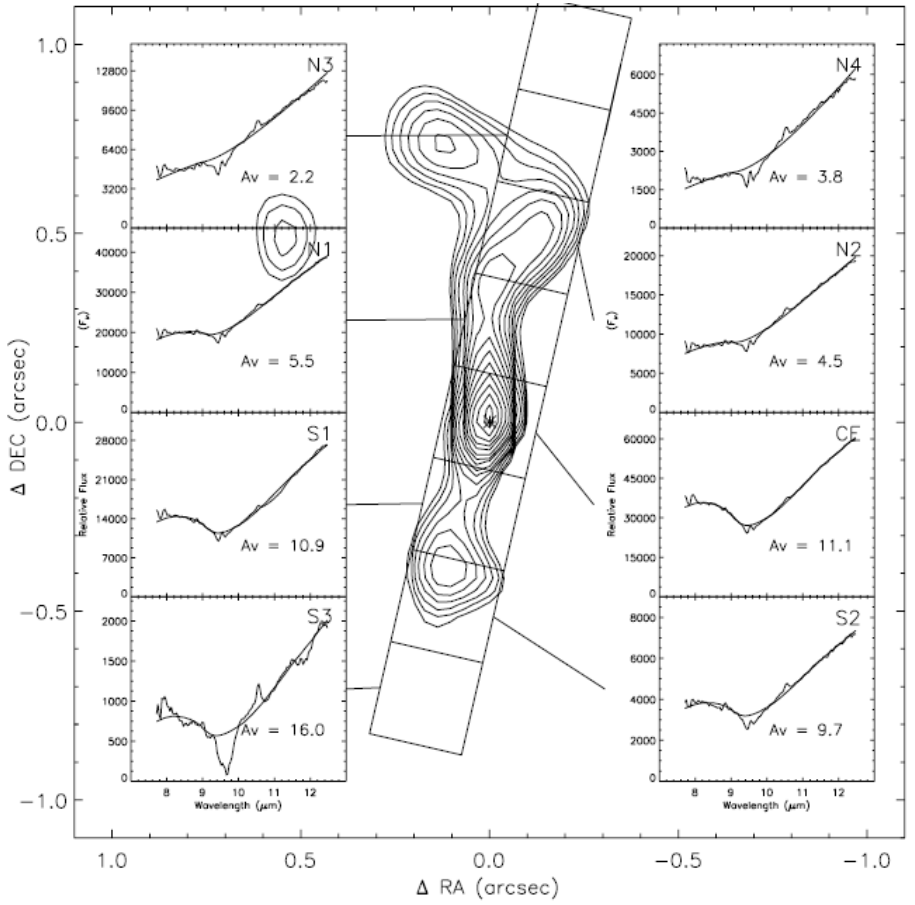
Iati et al. 2001



Li et al. 2008

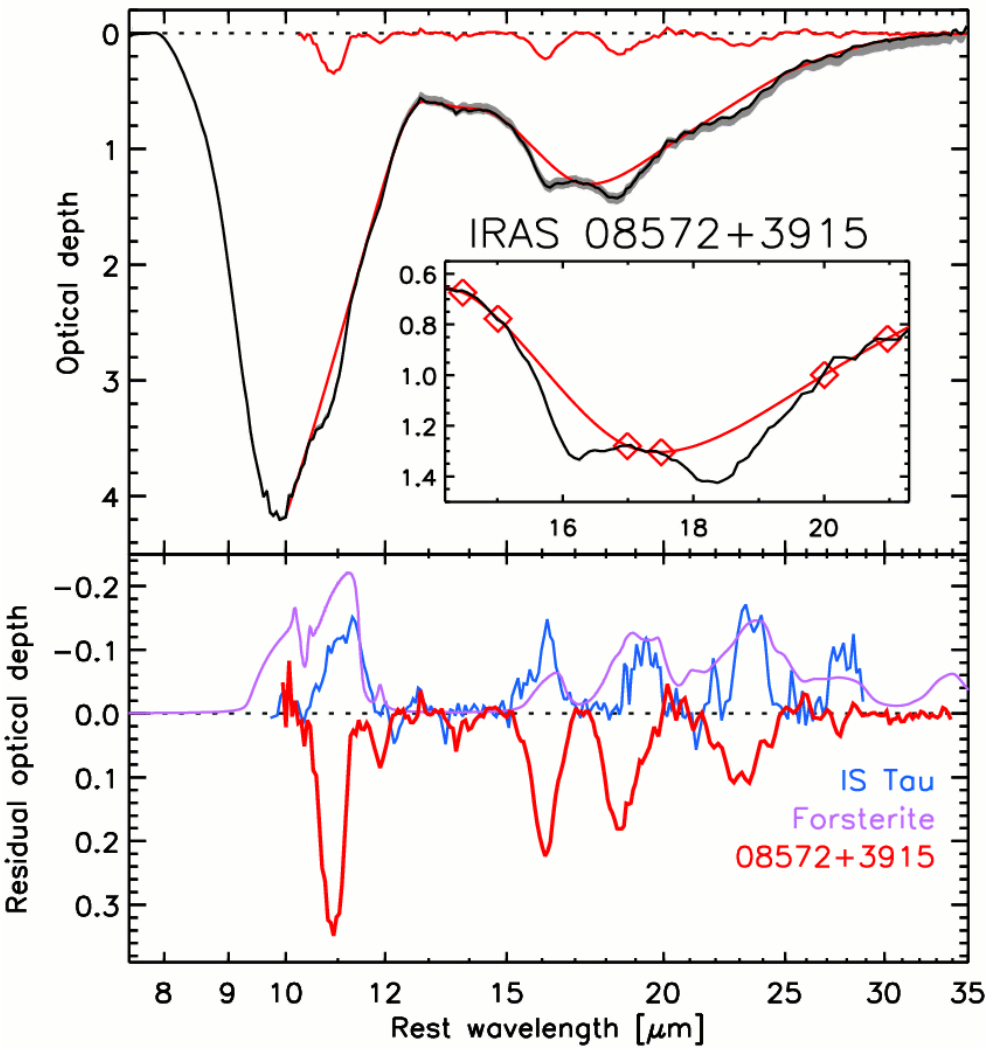
Spatial variations in NGC 1068 silicate: grain sizes





Rhee & Larkin 2006

Starburst galaxies: crystallinity



Spoon et al. 2006

Further reading

- A&A special issue on Herschel results: Volume 518, 2010
- Astromineralogy, lecture notes in physics 815, ed. Thomas Henning: chapter 2 & 3